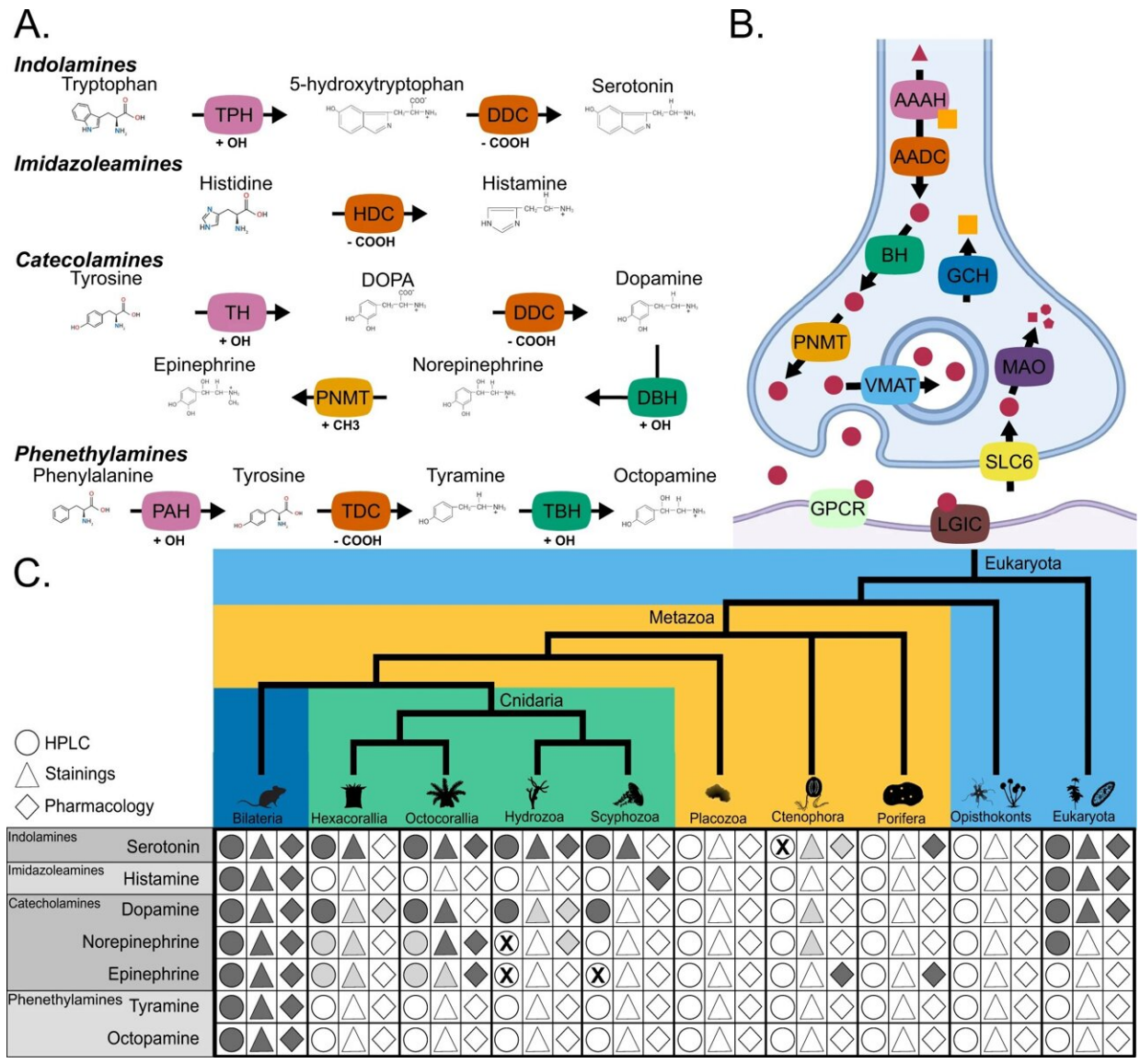
Genes for learning and memory are 650 million years old, study shows

July 14 2023



An overview of the monoamine system. **A** Synthesis pathways for key

monoamines including the substrate, chemical modification, enzymes, and products. Arrows indicate reactions with the facilitating enzyme overlain. For each enzyme, the label shows the name while the color indicates the gene family. Chemical modifications are shown next to the enzymes responsible. **B** Cartoon of a synapse with the different enzymes required for the production and detection of monoamines. The red circles represent monoamines and precursor molecules. Yellow squares represent tetrahydrobiopterin co-factor. **C** Current molecular evidence from the literature supporting the presence of monoamines outside Bilaterians in the literature. Dark gray indicates positive results, light gray displays uncertain or partial evidence (e.g., precursors, related compounds) and an X indicates negative results. Blank shapes indicate a lack of evidence. Staining refers to any chemical or immuno-staining experiments; pharmacology refers to evidence-based drug perturbations, adding inhibitors or other chemical interference experiments; HPLC High-Pressure Liquid Chromatography (see Supplementary Data 1 for references and details). PAH phenylalanine hydroxylase, TPH tryptophan hydroxylase, TH tyrosine hydroxylase, DDC dopa decarboxylase, TDC tyrosine decarboxylase, HDC histidine decarboxylase, DBH dopamine beta hydroxylase, TBH tyramine beta hydroxylase, PNMT phenylethanolamine-*N*-methyltransferase, AAAH aromatic amino acid decarboxylase, AADC aromatic amine decarboxylase, BH beta hydroxylase, VMAT vesicular monoamine transporter, GCH GTP cyclo-hydrolase, GPCR g-protein coupled receptor, LGIC ligand gated ion channel, SLC solute ligand carrier, MAO monoamine oxidase. (A) and (B) were made with Biorender. Silhouettes obtained from Phylopic.org. Silhouette images are by Christoph Schomburg (Dendronephthya gigantea); Daniel Jaron (Mus musculus); Emily Jane McTavish, from http://chestofbooks.com/animals/Manual-Of-Zoology/images/I-Order-Ciliata-41.jpg (Ciliophora); Konsta Happonen, from a CC-BY-NC image by sokolkov 2002 on iNaturalist (Geranium sylvaticum); Mali'o Kodis, photograph by Ching (http://www.flickr.com/photos/36302473@N03/) (Chrysaora fuscescens); Noah Schlottman (Pleurobrachia); Oliver Voigt (Trichoplax adhaerens); Steven Traver (Hydra); and Tess Linden (Salpingoeca rosetta). Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-39030-2

A team of scientists led by researchers from the University of Leicester have discovered that the genes required for learning, memory, aggression and other complex behaviors originated around 650 million years ago.

The findings led by Dr. Roberto Feuda, from the Neurogenetic group in the Department of Genetics and Genome Biology and other colleagues from the University of Leicester and the University of Fribourg (Switzerland), have now been published in *Nature Communications*.

Dr. Feuda said, "We've known for a long time that monoamines like serotonin, dopamine and adrenaline act as neuromodulators in the nervous system, playing a role in complex behavior and functions like learning and memory, as well as processes such as sleep and feeding."

"However, less certain was the origin of the genes required for the production, detection, and degradation of these monoamines. Using the computational methods, we reconstructed the evolutionary history of these genes and show that most of the genes involved in monoamine production, modulation, and reception originated in the bilaterian stem group."

"This finding has profound implications on the evolutionary origin of complex behaviors such as those modulated by monoamines we observe in humans and other animals."

The authors suggest that this new way to modulate neuronal circuits might have played a role in the Cambrian Explosion—known as the Big Bang—which gave rise to the largest diversification of life for most major animal groups alive today by providing flexibility of the neural circuits to facilitate the interaction with the environment.

Dr. Feuda added, "This discovery will open new important research avenues that will clarify the origin of complex behaviors and if the same

neurons modulate reward, addiction, aggression, feeding, and sleep."

More information: Matthew Goulty et al, The monoaminergic system is a bilaterian innovation, *Nature Communications* (2023). DOI: 10.1038/s41467-023-39030-2

Provided by University of Leicester